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BOSTON SOCIETY OF CIVIL ENGINEERS

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PAPERS AND DISCUSSIONS

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FLOATING DRY DOCK DESIGN

By J. Stuart Crandall,* Member Boston Society of Civil Engineers

(Presented before the Designers Section, March 14, 1923.)

In seeking the beginning or early history of any maritime industry we must turn to England. So it is with dry docks. Thus in the early days of shipping in England, where a great rise and fall of tide is available, it was the custom to beach a ship in a convenient spot at high tide where after the tide had receded the ship would be high and dry for repairs. A further improvement was to dig a basin into which the ships were floated at high tide and a gate closed so that after the tide had ebbed the ships were dry for a considerable period. This is the fundamental principle of the graving dock or basin dock.

In the time of Peter the Great a British sea captain once found himself with a leaky ship in the Baltic where the tidal variation was small and the usual means of dry docking could not be employed. He found, however, the hulk of an old ship "The Camel" somewhat larger than his own and from which he removed all the inner works and cut off the stern. This being done he floated his own ship into it and closing the stern with an improvised gate, pumped the water from the hulk which thus floated with his ship inside dry and accessible. This is the first recorded instance of the use of the underlying principle of the floating dock.

* Treasurer, Crandall Engineering Company.

After this occurrence a number of such "Camel" type floating docks were built and operated in England and the Continent, the first being built in 1776. From their structure they were neither strong nor stable and were usually operated between rows of piling to keep them upright. The illustration (Fig. 1) shows a floating dock of the "Camel" type which was

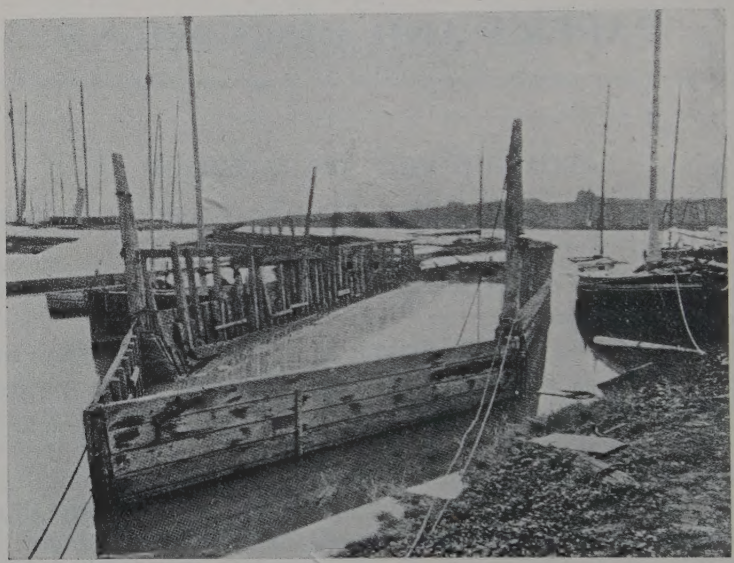

FIG. 1. — "CAMEL" TYPE FLOATING DOCK.

still in existence twenty years ago. There is a "Camel" dock now in use on the Lakes at Midland, Ontario, similar to the one in England used nearly 150 years ago.

As ships became larger the size and capacity of floating docks increased and their construction called for more and more careful design and engineering. It would be interesting to follow the evolution from this primitive type to the modern embodiments of the same principles and functions, but the subject would be too lengthy for this paper. It will suffice to say that design in the different maritime countries has been governed greatly by the construction materials available. In England and on the Continent where timber is scarce floating docks have

largely been constructed of iron and steel. In this country with our abundant, but regrettably fast diminishing timber supply, floating docks have been built largely of wood. In England with its maritime tradition much attention has been given to floating dock design. The London firm of Clarke & Standfield have examples of their engineering skill in ports throughout the world. Their docks have all been built of steel. In Germany, until shortly before the war, most of the floating docks were of English design by Clarke & Standfield but since that time the Germans have built a number of their own design, which, apparently in accord with the German characteristic, are marvels of intricacy but which do their work no better than the more simply operated types.

In this country it does not appear that much engineering attention has been given to floating dock design. With the exception of a few shining examples most of our floating docks have been built largely by muscle and to rule of thumb. Much ingenuity has been displayed in the construction but due to lack of engineering foundation they are frequently weak and expensive structures.

Before going further it will be in order to describe the *floating dry dock* and its functions. A floating dock may be described as a buoyant structure designed to lift from the water, upon itself, ships and other floating craft for examination and repairs with a minimum loss of time. In doing this the ship should not be subjected to undue distortion but held in line as rigidly as possible. The efficiency of a dry dock may be stated roughly as the degree to which these conditions are fulfilled considering the first cost, maintenance and amortization. Floating docks being of destructible material must themselves be occasionally lifted from the water for examination and repair and if there is no larger dock available for that purpose they must possess self-docking features.

Modern floating docks resemble in cross-section a hollow letter U or letter L so arranged that, to sink the dock to the desired depth, water is admitted into the hollow section and then the dock raised, with the ship on it, by pumping out this water. With suitable bulkheads to reduce the free water area

the U dock is stable at all elevations. This is plainly not true with the L type which must be equipped with a counterbalancing arrangement to maintain stability. Pumping is usually accomplished by centrifugal pumps and should be so arranged that the quantity of water pumped from the several compartments may be governed at will. These pumps are usually located at the bottom of the dock under the wing walls with the suctions and piping arranged to suit the system of control installed.

Fig. 2 illustrates the U and L types. The counterbalancing arms of the L type in one case are fastened to a permanent shore

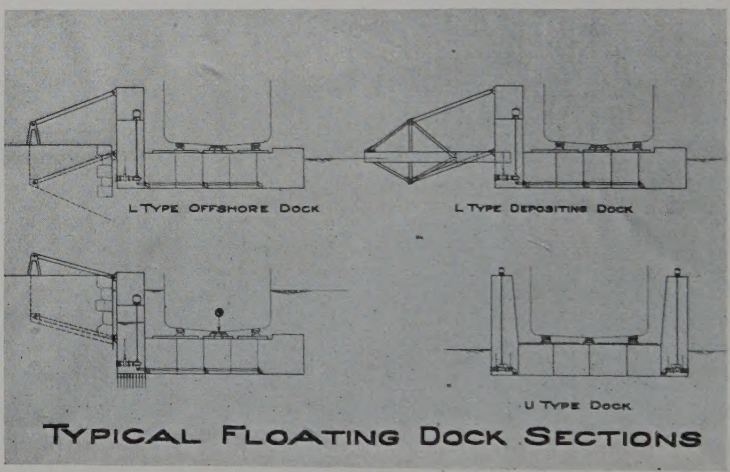

FIG. 2. — U AND L TYPE FLOATING DOCKS.

mooring and in the other to a floating counterbalance pontoon. This second type was the first use of the L shape, being the so-called depositing dock. The bottom part of the L is made up of a series of fingers which correspond with a similar series of fingers in a permanent marginal dock (Fig. 3). When a ship is lifted the dock and ship are floated over the marginal dock and the fingers interlaced. The floating dock is then lowered leaving the ship on the marginal dock. This type is limited to use in localities where there is no undertow and to a basin with little variation in water level. It may be criticised for lack of longitudinal rigidity, the ships being obliged to withstand longi-

tudinal bending due to unequal loading or uneven pumping. By building these docks in two or more sections the matter of self-docking is a simple one, disconnecting one section and raising on the other sections. A few of these docks have been built

FIG. 3. — DEPOSITING DOCK.
Barrow-in-Furness, England.

and are in use in England and elsewhere but due to their limitations other types are preferred.

The offshore dock or L dock with permanent shore connection (Fig. 4) is an outgrowth of the depositing dock. In this latter type however the pontoon is not cut up into fingers but is continuous, and by means of longitudinal bulkheads, trusses and better connections with the wing wall, can be designed to resist considerable longitudinal bending moment.

For self-docking this type is made of two or more sections bolted together so that one section may be separated and lifted on the rest as with the depositing dock. These docks have been rather popular with the English and quite a number are in operation.

With only one wing wall to resist longitudinal flexure the use of this type for the larger floating docks would require

large wing flange section to give adequate resisting moment. For this reason the larger docks are usually of the U type.

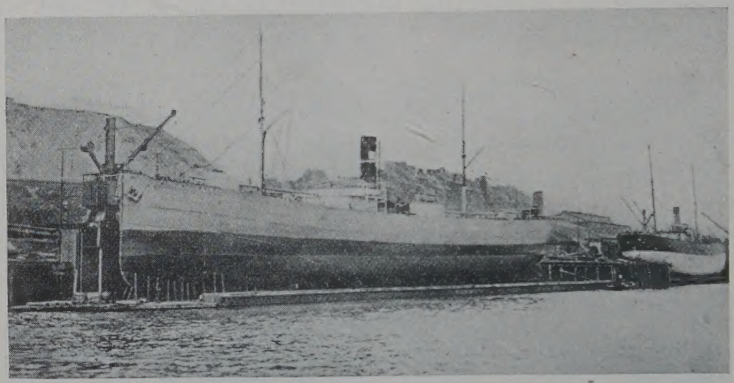

FIG. 4. — OFFSHORE DOCK.
North Shields-on-the-Tyne, England.

The U section, which is the oldest, with its two wing walls can better take care of the longitudinal bending stresses as can be readily seen. The necessity for self-docking has given rise to some ingenious arrangements. The U section is particularly interesting to us because not only are most of the floating docks in the world of this shape but also all those in this country. The simplest is the so-called box dock which is not self-docking (Fig. 5). The wings and longitudinal bulkheads being continuous, such docks can have maximum longitudinal stiffness with a minimum section and weight. For smaller docks which may be dry docked in larger ones this type is the least costly and most adaptable. In this country most of the box docks are of wooden construction, in Europe of steel.

When it becomes necessary to design a U dock with self-docking means, the first and logical idea was to cut the dock into a number of sections so that one section could be docked on the others. The physical connection between the sections was of a loose sort just enough to keep the sections somewhere near their relative locations, — these connections being made with rope, chain or otherwise. Fig. 6 shows such a loose connected sectional dock used in Europe. The three pontoons are

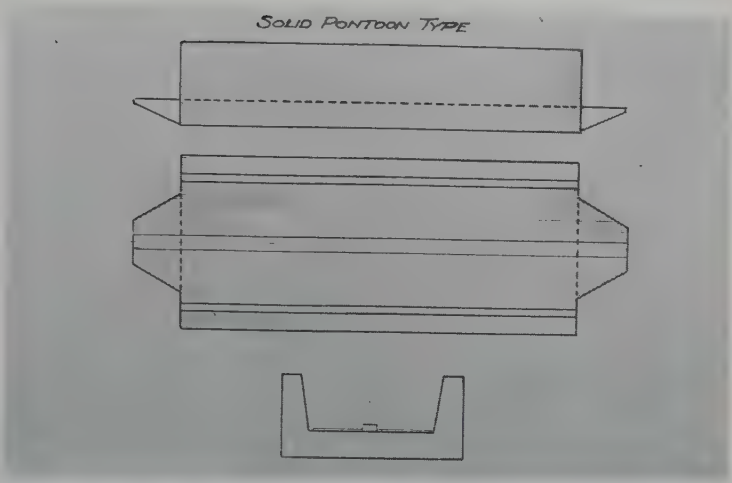

FIG. 5. — BOX OR SOLID DOCK.

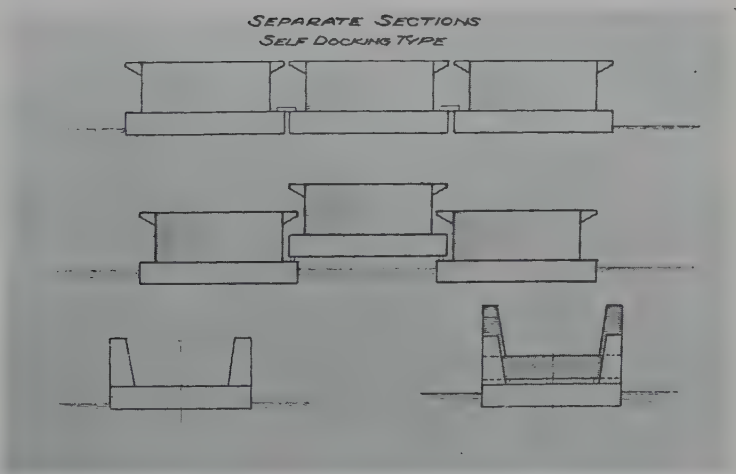

FIG. 6. — LOOSELY CONNECTED SECTIONAL DOCK.

of steel held together by chains. For self-docking a section is lifted between the other two on the projecting pontoon ends. This is a very simple method of obtaining self-docking but when we consider the effect on ships it can readily be seen that with no means of transmitting shear and bending between the sections, ships being dry docked must withstand any bending due to unequal loading or pumping. This is the great fault of all loosely connected sectional docks. Although a ship must withstand the buffeting at sea it should not be subjected to any large bending stress or deflection when dry docked.

The first effort in England to overcome this lack of longitudinal stiffness resulted in another type, the so-called "Rennie"

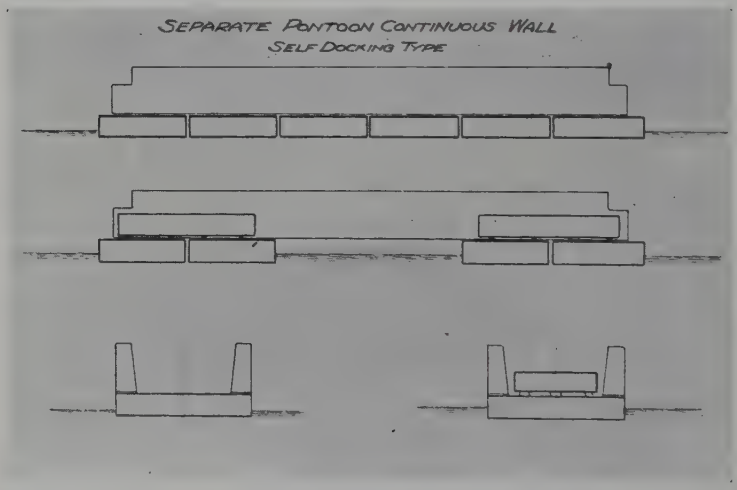

FIG. 7. — "RENNIE" TYPE FLOATING DOCK.

type (Fig. 7). This consists of continuous wing walls resting on and fastened to a number of separate pontoons. By this arrangement the wings give longitudinal rigidity and the pontoons may be disconnected and dry docked on the others. It has the fault that available chord distance is limited to that from the deck to the top of the wing with the result that heavy chord sections must be used to obtain proper resisting moment. A number of docks of this type with steel pontoons and wings

were built in England, the Netherlands and elsewhere but few have been built in Europe within the last twenty years because the designers, appreciating the inherent defect mentioned, have turned to other and more efficient types.

To overcome this fault of the "Rennie" dock, Clarke & Standfield devised another type for steel construction (Fig. 8). The wings for the full depth to the bottom of the dock are made continuous, with the pontoons in three sections, between and bolted to the wings. By this arrangement the full depth of the

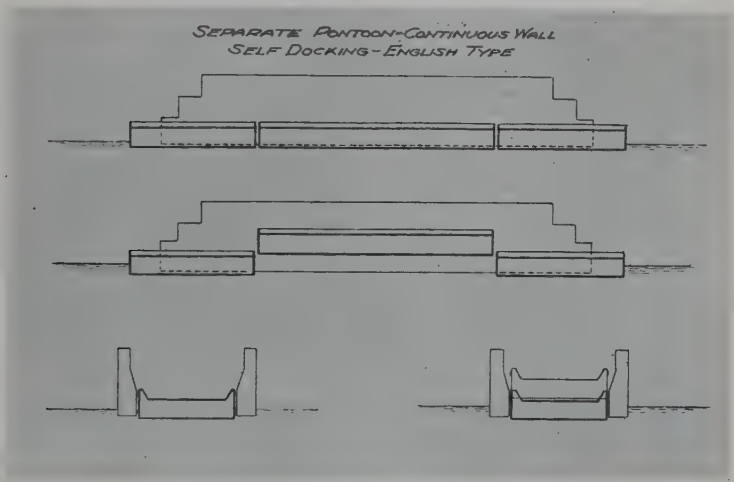

FIG. 8. — "CLARKE & STANDFIELD" TYPE.

wings is available to resist longitudinal bending. For self-docking the end sections are removed one at a time and docked on the middle one. To lift the middle section it is first disconnected from the wings and the rest of the dock lowered until the middle section corresponds with connector plates higher up on the wings. Here the middle section is bolted and then by pumping out the wings and end sections the middle section is lifted clear of the water. The submerged parts of the wing walls are unwatered for repairs by admitting water to one side of the dock thus careening it until the bottom of one wing is above the water. A number of these docks have been built and are

operating successfully. The U. S. Naval Dock at Algiers, La., of 18,000 tons capacity is of this type. This type has the fault that heavy loads must be transmitted to and carried by the bolted connections resulting in rather high load concentration which necessitates heavy sections. For this reason docks of this type are no longer being built.

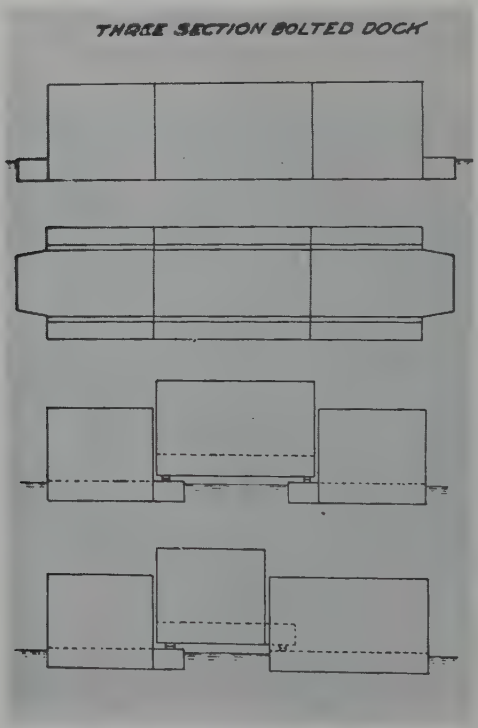

Fig. 9. — Three Section Bolted Dock.

To overcome this fault the later designs in steel were made with the three sections bolted together around the periphery thus forming a rigid unit which can resist considerable bending and yet so arranged that upon occasion the sections may be unbolted and separated for self-docking. Fig. 9 shows the principle of this type and the method of docking the sections.

Other docks have been built on a similar principle with more than three sections, the sections being of such length that when turned around through 90 degrees each may be docked on the other sections. A floating dock of this kind is now being built in Southampton which when completed will be the largest in the world as it will be capable of lifting 60,000 tons. With careful designing particularly as to the joints between the sections this type solves satisfactorily the problem of securing longitudinal rigidity as well as means of self-docking.

Turning to this country we find that here the loose sectional dock has its greatest development, a large percentage of

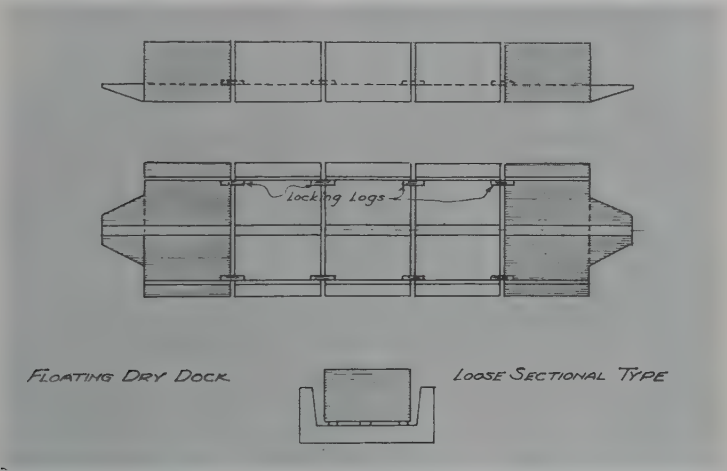

FIG. 10. — LOOSE SECTIONAL DOCK.
In common use in United States.

American floating docks being of this type, all of timber construction (Fig. 10). The sections are usually made of such a length that by disconnecting one and turning it crossways it may be docked on another section. The connection between the pontoons is usually a large square timber called a "locking log" which can hold the sections at their proper distances apart and do little more. This type has the fault of its steel counterpart in that there is no means of resisting longitudinal bending.

This becomes more important when it is considered that these docks are not usually equipped with any indicators to show the depth of the water in the various compartments of the dock so that there may be a wide difference in the buoyancy of the several pontoons without any visual evidence. The resulting bending moment that may be set up in a ship is quite apparent. To cite an extreme example a few years ago a car float was lifted on a two-section floating dock somewhat shorter than itself thus giving the float a considerable overhang at each end. After coming off of the dock the float had 36 inches of "hog" although straight when it was dry docked. A number of other instances might be cited where ships have been crippled by bad docking in such docks. In January of this year a steel Lake Borgne Canal steamer was broken in two while being lifted on such a dock at Mobile.

The Shipping Board were apparently unable to depart from the traditions of the loose sectional dock and bring out a

FIG. 11. — "SHIPPING BOARD" LOOSE SECTIONAL DOCK.
Note line of wings.

design that would better fulfill the requirements for a dry dock. Fig. 11 shows a Shipping Board dock with a steamer entering

it. It might be said here that the Shipping Board docks have 28 inch square locking logs and these frequently are broken while operating the dock.

A number of docks of the Rennie type with timber pontoons and steel wings have been designed and built in this country and most of them are operating successfully. There is one instance where a dock of this kind failed by rupture of the wing but whether it was due to faulty design or improper operation has not been determined. Although having the in-

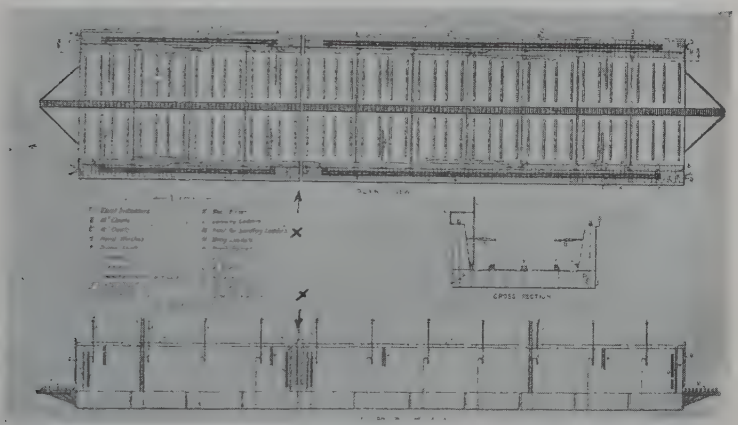

FIG. 12. — "RENNIE" TYPE WITH STEEL WINGS AND WOODEN PONTOONS.
Wings cut at "X".

herent defect of the Rennie type, — shallow girder depth of the wings, — they are far superior to the loose sectional type as is quite apparent. Up to certain capacities this type is a good solution of the problem of obtaining adequate longitudinal resisting moment combined with means for self-docking. It seems rather unfortunate that some of these docks are built with the wings in two sections (Fig. 12) rather loosely connected together for by such a construction the benefit of the continuous wing is lost and there is nothing but the ship to resist bending.

One dock of this type has been built with continuous wooden wings and separate pontoons but has been found so

limber that it has even thrown the dock machinery out of line and caused considerable trouble.

To overcome lack of longitudinal rigidity of the loose sectional dock and still retain the other advantages particularly for timber construction our company developed the longitudinally-

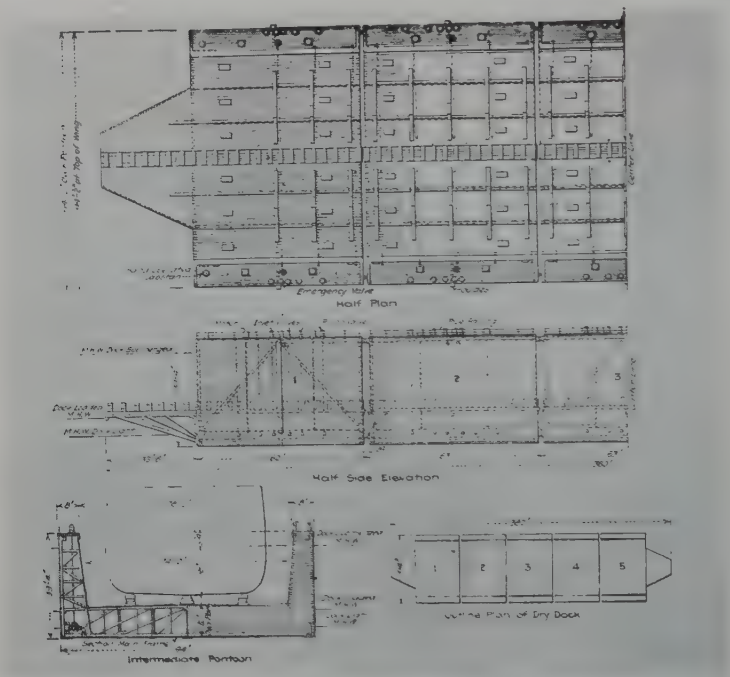

FIG. 13. — LONGITUDINALLY-TRUSSED FLOATING DOCK.

trussed sectional dock (Fig. 13). In this type the panel of a Warren truss is constructed in the wing wall of each section. At the panel points are steel castings with corresponding lugs which when pinned together form the dock into a rigid unit with a Warren truss in each wing for longitudinal stiffness (Fig. 14). The lugs of these steel castings are connected in each case by a single pin thus four pins only are used to join the sections. For self-docking it is only necessary to remove these four pins, turn a section through 90 degrees and dry dock it on the others (Fig. 15).

By this method of construction the chord distance is made almost the entire height of the dock giving the greatest possible stiffness with a reasonable chord section. These trusses in the timber docks are made up of timber compression members held between the terminal castings by steel tension rods. The trusses are designed to withstand a fair sized longitudinal bending moment and thus safeguard the ships from undue distortion.

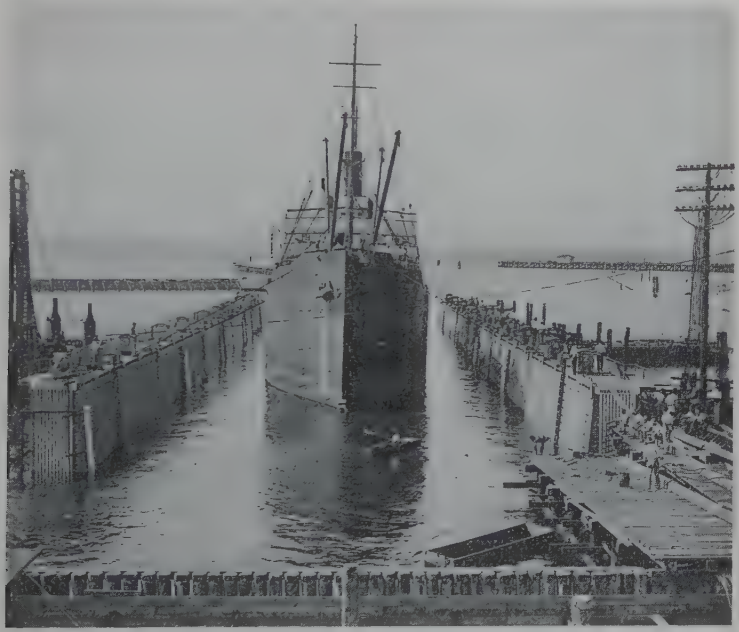

FIG. 14. — SHIP ENTERING LONGITUDINALLY-TRUSSED DOCK.
Note line of wings.

Practical in theory these docks are proving efficient in operation (Fig. 16). As an instance of what the trusses will do a large six masted schooner was being dry docked on an 8,000 ton floating dock of this type. The schooner was supposed to have 30 inches of "hog" and the keel blocks were so set. As the dock was pumped up it was found that the bilge block did not fit properly so a diver was sent down. He found that in-

stead of 30 inches there was 61 inches of hog. The owners were informed and they decided to straighten out the hog to 30 inches. The ship was then shored against the wings and the dock pumped up. Observation of the line of the wings showed that there was no appreciable longitudinal deflection of the dock and when the ship was clear of the water it was found resting on all the keel blocks, the 31 inch hog having been removed. It is practically impossible to determine the bending moment in

FIG. 15. — TWO SECTIONS OF 8,000 TON LONGITUDINALLY-TRUSSED DOCK.

the dock due to this operation but it was evidently no small figure.

It would be an omission not to mention the "Dewey" dock which was built for the Navy and is now in Manila (Fig. 17). This dock was designed to meet rather extreme Navy specifications which required a maximum longitudinal resisting moment, a deflection of only 1 inch in 2,000 inches being allowed considering the ship load to be absolutely flexible, and the pumping uniform. It was designed in steel with the wing walls continuous and integral with the pontoon for most of the length. At each end the wing walls were cut off near the deck level

FIG. 16. — 5,000 TON LONGITUDINALLY-TRUSSED DOCK.
Pensacola, Florida.

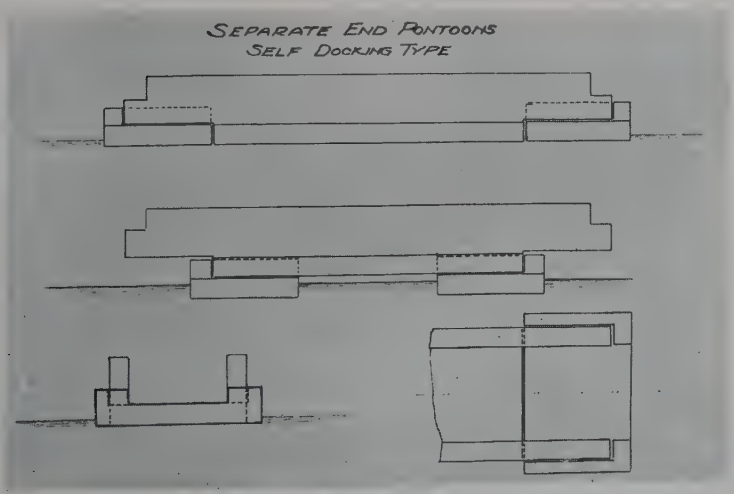

FIG. 17. — U. S. NAVAL FLOATING DOCK "DEWEY."

where separate end pontoons were bolted to them. These end pontoons were made somewhat wider than the dock so that they could be detached, lowered and floated under each end of the main dock and then pumped out lifting the dock clear of the water. The end sections are of such a length that they may be detached and docked on the middle pontoon. This type with some possible modifications is a good one for all steel construction. However, due to the rather extreme requirements this dock has about 50 per cent more steel than commercial docks of the same capacity having 9,200 tons of steel whereas the Bermuda dock has 6,700 tons. For commercial work such extreme weight would be fatal.

In a general way this paper has covered the types of floating docks now in operation. Just as no one kind of dry dock is best for all conditions so no one type of floating dock is suited for all localities and all kinds of service. Each project must be studied individually taking into account the various economic factors before the proper type can be chosen which will best suit the case.

Design

Now to turn briefly to the element of design, taking for example an 8,000 ton longitudinally-trussed dock of timber. Design in steel would be analyzed in a similar manner with due allowance for the different nature of the material and the most economical framing. As timber becomes scarcer and more costly more steel will be used in floating docks despite its probable shorter lifetime. Coming to the design: first, what are the exterior forces acting on the dock? There are:

1. Weight of dock.
2. Weight of ship.
3. Upward water pressure on bottom.
4. Downward water pressure on deck.
5. Weight of water in dock.
6. Water pressure on wing walls.

The last one is largely compensating or affects only strength of the wing frames and side plating. The weight of the dock is

constant. All of the other forces vary with the depth of the dock in water. These must be investigated in conjunction with one another to determine the critical points. To illustrate more clearly take for example an 8,000 ton longitudinally-trussed dock.

Before doing this it is well to note that there are about four different loading conditions (Fig. 18):

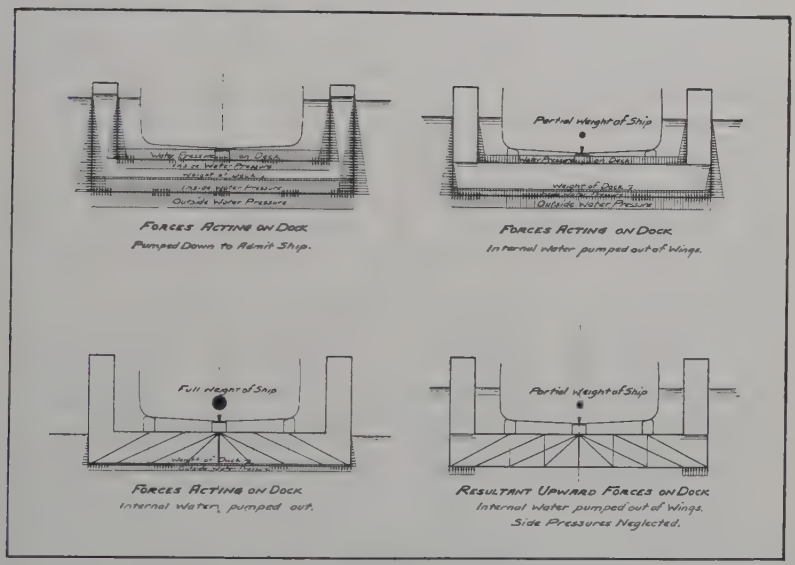

Fig. 18. — Loading Conditions on Floating Docks.

1. Dock light, when, due to the weight of the wing walls there is a negative transverse bending moment.

2. Dock sunk to limit, when there is no load on the dock and the stress practically nothing.

3. Dock with partial load when water in wings is just pumped to dock level. At this point the weight of ship is carried by the unbalanced upward pressure under the wings causing greatest stress in the outer braces. At this point the stress in the exterior braces is a maximum.

4. Dock fully up with load, at which point there is the maximum stress in the interior bracing.

Fig. 19 shows the method of determining the critical points. The curve marked "Displacement" is drawn with tons of displacement of the dock as abscissæ and draft of the bottom of the dock as ordinates. The break in the curve indicates the point where the wings meet the pontoon of the dock. The weights shown are those of one section. With a calculated weight of 750 tons for this section this curve gives a draft of 3.6 feet. Moving this curve bodily to the Y axis until the

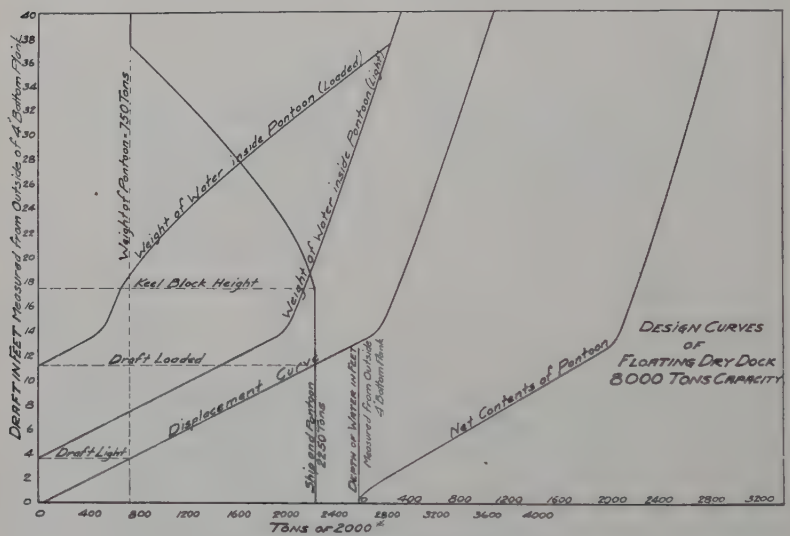

Fig. 19. — Method of Determining Critical Points.

curve coincides with this point gives the curve "Weight of Water Inside Pontoon with Dock Light." From the displacement curves of the ship we can construct the next curve which gives the weight of vessel and dock at different drafts. The difference between the abscissæ to these curves gives the curve "Weight of Water Inside Pontoon with Vessel." Another curve is also shown being the relation between the depth of water inside the dock and the quantity of water in the dock.

To obtain the head against which the pump must operate at different times other curves are drawn as shown on Fig. 20. With depths of water in the dock as abscissæ and draft of the

dock as ordinates, curves are drawn showing the height of water in the dock for all drafts for the dock light and loaded. The difference between the draft of the dock and the inside depth is the head and from these differences the curves for head are drawn. From these curves are obtained most of the design data, the mean and maximum head against which the pumps must work, the water pressure conditions, and other details of the exterior forces.

The transverse trusses which distribute the weight of the ship evenly to the bottom of the dock are double system trusses.

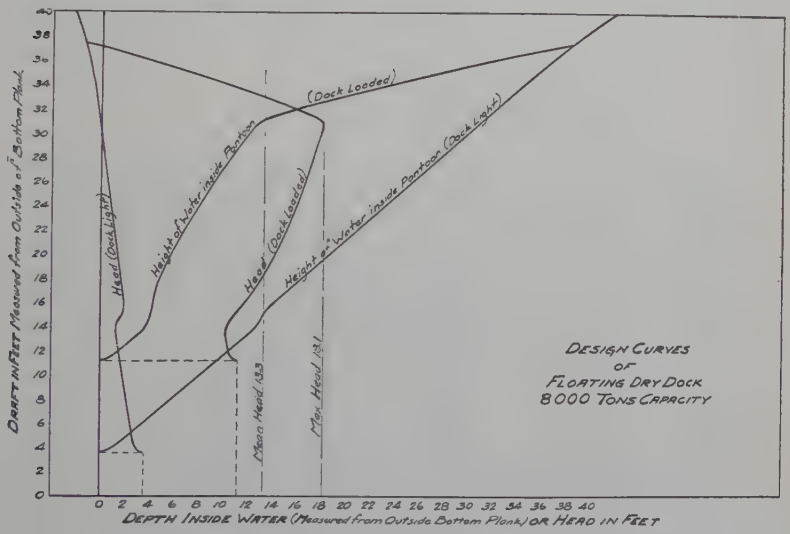

Fig. 20. — Method of Determining Head on Pump.

Each member of these trusses must be designed for the load condition which produces the most severe stress in that particular member. For example, when the inside water level has just reached the deck level the weight of the ship is supported by the water pressure under the wings causing maximum stress in the outer braces. Under this condition the deck system, stanchions, and planking are also subjected to maximum head due to the external water pressure. The inner braces are under maximum stress when the dock is fully up with a capacity ship.

Another loading condition which must be investigated is that when the dock is light and not supporting a ship. Under this condition a negative bending moment is set up in the cross frames due to the weight of the wing walls. It is quite apparent therefore that this light condition is also a critical one.

As the actual conditions of loading and pumping vary so the longitudinal bending moment is affected. To make certain that the dock has ample longitudinal resisting moment it is usually assumed that a full capacity load is lifted bearing on only five of the six sections. This allows for a resisting moment in foot tons about equal to three times the capacity of the dock.

Fig. 21 shows a completed 8,000 ton dock the design of which was based on the foregoing principles.

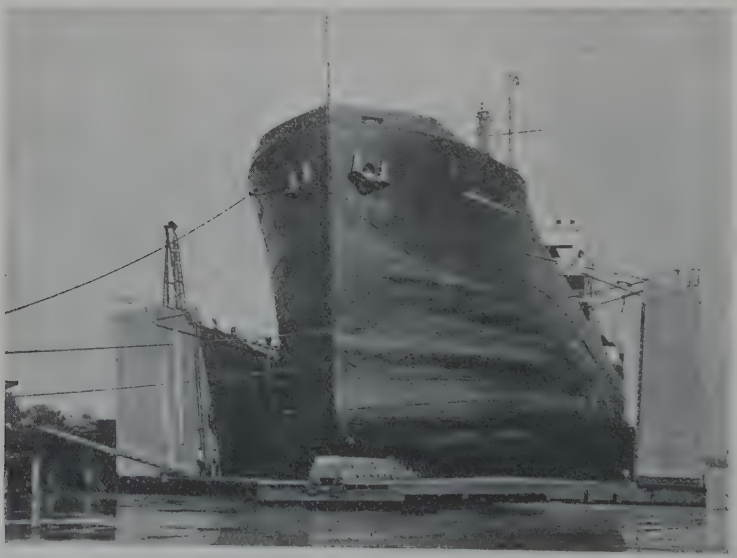

FIG. 21. — 8,000 TON LONGITUDINALLY-TRUSSED FLOATING DOCK. New Orleans, Louisiana.

This covers, in a brief way, the elements entering into the analysis of stress in floating dry docks. In this country little attention has been given to the matter of longitudinal rigidity,

while in England the necessity for this has long been recognized. It is believed however that as shipowners and underwriters in this country grow to appreciate the value of longitudinal rigidity in floating docks that they will be more and more reluctant to dry dock their ships in floating docks which cannot fulfill this requirement.

Only in design based on such analysis can there be assurance of the best and most economical distribution of material in the floating dock structure and thus the lowest cost commensurate with proper strength. In these days of keen competition such factors may be vital to the life of a ship repair organization.

THE CONSTRUCTION AND MAINTENANCE OF BITUMINOUS MACADAM ROADS

By Raymond W. Coburn *

(Presented before the Northeastern Section, American Society of Civil Engineers, May 12, 1923.)

I am glad to have an opportunity to discuss this subject, for in some states and municipalities the Bituminous Macadam Road is "sort of on probation"— and has been unjustly criticised and condemned as being too expensive to maintain and therefore a waste of public money to build.

This point of view I am not able to reconcile with my knowledge of good Penetration work. It is my belief that the Penetration type of road still has a wide field for use, wherever trap rock or other suitable stone is available, and in many places it can be built and maintained more economically than any of the more expensive types of modern pavements.

I shall deal first with the *construction* of the road, and will state here that if the road has been properly designed, honestly and conscientiously constructed by a trained man, and the work carried on during the proper season of the year, the *maintenance* should be a very small item.

History and Types of Bituminous Macadam Roads

Before going into the details of the construction, it will be well to define what is meant by a "Bituminous Macadam Road," to consider briefly its history and to enumerate the different types.

The definition adopted by the Association for Standardizing Paving Specifications is as follows: "Bituminous Macadam Pavements are those consisting of broken stone and bituminous materials incorporated together by penetration methods."

The Penetration type of road is comparatively new, having come into popular use during the last fifteen years. Its

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popularity was due to the fact that the automobile was fast destroying the old waterbound macadam roads and a binder other than dust and water was necessary. During the period from 1908 to 1911 the increase in yardage of this type in Massachusetts and six other States was one hundred fold. To Massachusetts, perhaps, as much as to any other State belongs the credit for this pioneer work, and it may be considered pioneer work, for this type was still in its experimental stages up to 1912, at which time our standard type of Penetration was developed. It can be safely said that up to this time heavy asphalts had not been sprayed by distributors under pressure. Lighter materials had been used and the work was done by hand or other crude methods.

There are three different types of Bituminous Macadam Pavement which have been developed in this State, as follows:

(1) Bituminous Macadam Hot Oil.
(Used previous to 1912.)
(2) Johnson Type.
(A Tar Penetration.)
(3) Massachusetts Standard Type. — #1 Stone.
(Both Tar and Asphalt used. — Developed in 1912).

The first type, the Bituminous Macadam Hot Oil, is not considered a modern type and is no longer being built, but 35 miles of it are still under maintenance in Massachusetts.

This type was laid during the experimental days up to and including 1911. It was constructed by spraying about $\frac{3}{4}$ gallons per square yard of 90% Asphaltic Oil on top of a waterbound macadam base or a gravel base, — then about 2 in. of #2 stone was spread evenly over the oil blanket and rolled into the oil with a steam roller. Next, $\frac{3}{4}$ gal. per sq. yd. of the same kind of oil was sprayed into the #2 stone and later covered with sand and pea stone and then rolled. Sometimes, if necessary, a light seal coat of about $\frac{1}{4}$ of a gal. per sq. yd. was further applied and again covered with sand and pea stone.

The second type is the "Johnson Type," so-called because it was developed and has been extensively used by John A. Johnson, District Engineer, Division of Highways in the Massachusetts Department of Public Works.

Briefly, it consists of first laying a carefully prepared stone base of ledge or field stone, — the larger stones being placed on the bottom and chinked up and brought to grade with smaller stones so that after rolling and having the voids filled with sandy gravel, the surface of the stone base shall be 2 in. below and parallel to the proposed finished surface of the road.

Then 2 in. of #1 stone is spread on top of the stone base, rolled and covered uniformly with about $\frac{1}{10}$ of a cubic yard per sq. yd. of clean sharp sand, so that after rolling again the sand fills the voids in the stone about halfway to the surface.

Next, the stone is lightly sprinkled with water, and tar having a consistency of 70 to 120 by the Float Test, is applied under pressure at the rate of $\frac{1}{4}$ gal. per sq. yd. #2 stone is next spread uniformly over the bitumen at the rate of 0.02 tons per sq. yd. and the surface is rolled. The surface is then sprinkled again, and tar, at the rate of $\frac{1}{2}$ gal. per sq. yd. is sprayed into the #2 stone, and the surface is covered with pea stone and rolled.

Finally, the surface is sprinkled for the third time with water, and a seal coat of $\frac{1}{4}$ gal. per sq. yd. of tar is applied, and then covered with clean, coarse sand and thoroughly rolled.

The third type, known as the Massachusetts Standard Type with #1 stone, is the one with which we are most familiar. It consists of a 2 in. to 3 in. top, or wearing surface, of #1 stone, bound with asphalt or tar. This top surface is usually laid on a broken stone base 4 in. to 5 in. in depth, which has been thoroughly rolled and bound up with dust or sand almost like a waterbound macadam road.

Construction of Massachusetts Standard Type

It is this last type of pavement which will be considered in this paper, treating it briefly under the following headings:

1. Materials used in the construction.
   (Stone and bitumen.)
2. Machinery and equipment necessary for proper construction.
   (Roller, kettles, asphalt wagon and motor distributor.)
3. Inspection of work in field.
4. Method of carrying on the work.

Materials

The materials necessary for the construction of a good Bituminous Macadam road are first a good hard and tough stone, and second, a good grade of bituminous material, either asphalt or tar of the proper consistency. The stone should preferably be a good commercial trap rock or a local stone of its equivalent, having a French coefficient of wear of not less than 12 and a toughness of not less than 8. It should be available in #1 sizes, that is from $1\frac{1}{4}$ in. to $2\frac{1}{2}$ in. or $2\frac{3}{4}$ in. The bituminous material may be any one of three kinds which shall have certain prescribed properties and among other requirements must meet the following:

A. Fluxed native lake asphalt shall have a penetration of 120 to 150.
B. Oil Asphalts shall have a penetration of 90 to 120.
C. Tars shall have a consistency of 120 to 180 by the Float Test.

Penetration at 25 degrees Cent. (77 degrees Fahr.) 100 G., 5 Sec.

These three kinds are illustrated by their trade names as follows:

Bermudez — A fluxed native asphalt.
Binder B — An oil asphalt.
Tarvia X — A coal tar product.

Machinery and Equipment

The amount of machinery and equipment necessary for this work is probably smaller than for any other type of modern pavement. For that reason it is popular in cities and towns where they do not care to own expensive machinery. Provided the stone is trucked to the job and the bituminous material sent out from a heating plant in a motor-sprayer, about the only machinery needed on the job is the steam roller.

In case the work is to be done at a considerable distance from any commercial quarry, and too far to send bituminous material by truck, then a stone crusher would be needed, kettles

in which to heat the bituminous material, and a spraying wagon for applying it. It has been my experience that with a trained organization, just as good and perhaps better work can be done with the wagon distributor hitched behind a roller as with the motor-sprayer, the following roads built with the wagon being given as examples, — Dracut, Manchester, Concord, Acton, Wayland and Sudbury. I should add, however, that today where work is being done within trucking distance of a bituminous heating plant, it is cheaper and it facilitates the work if the motor-sprayer is used.

Inspection

The inspection in the field is the most important phase of the work, and it is my opinion that more Penetration roads fail because of poor workmanship and poor inspection, than from any other cause. A Bituminous Macadam road may fail from poor design, because foundations were omitted where they were needed, or the road built too thin, or it may fail because of poor quality or too little bituminous material, but I believe that more failures are due to other reasons and that the majority of them could be prevented if the inspectors were properly trained in the details of the work. My advice to any man who wants to make a success of this kind of work is to leave off the white collar and good clothes. The work is dirty, and no man can see what is going on unless he is willing to so dress that he can get into the midst of it.

Method of Construction

The first step in the construction of the Penetration road is the provision for adequate drainage. In loamy or clayey soils a subgrade of gravel 12 in. deep should be laid or a stone base on top of about 4 in. of gravel. In wet and springy ground, side drains should be built with broken stone and open-jointed sewer pipe, or ditches should be provided along the sides of the road in order to keep the ground water out of the subgrade.

Having drained the road and provided suitable subgrade, the next step is to roll the subgrade thoroughly with a steam roller until no settlement can be discerned.

Base Course. — Upon this compact subgrade there is then spread a layer of broken stone, preferably #1 stone, but if it is necessary to use the output of a crusher, then the #1 and #2 stone may be mixed, being careful that they are mixed uniformly and that there is not an excess of the #2 size. This layer should be carefully spread, either from dumping boards or from self-spreading trucks, and after rolling should have a perfect cross-section 2 to $2\frac{1}{2}$ in. below the desired finished surface. If depressions or bumps are visible, they should be carefully patched or removed, for the more perfect the base is made, the easier it is to get a perfect top surface. The usual thickness of the base course is 4 in., but where travel is very heavy, 5 or 6 in. may be used. After the base course has been bound up with the binder and rolled until it is thoroughly compacted, it should resemble somewhat a waterbound macadam surface, except it is not bound up so tightly. The surplus binder is then broomed from the surface and the top or wearing course can be spread.

Top Course. — The best results will be obtained in the top course if #1 trap rock is used, being careful that there is no #2 or finer stone mixed with it. This trap rock should be spread from a dumping board with forks and the dust, dirt and small stone left on the board thrown to one side and wasted. This is important, for with almost every truckload of broken stone there is a bushel or more of dirt and small stones, and if this is left in the road in one spot, as is likely, the proper penetration will not be obtained when the bitumen is applied, as the voids will be partly filled with dirt. Furthermore there would probably be a blot or "fat place" on the surface where the bitumen could not penetrate.

Having spread the top stone carefully from dumping boards and having done all the patching that can be seen at the time, the top surface should be lightly and carefully rolled and the patching continued until the road surface looks absolutely perfect. The patching should be done with #1 stone only, and it is important to do it before the surface is rolled too much, as it is very hard to roll a patch into a well rolled road. The top course is usually 2 in. thick, but I prefer about $2\frac{1}{2}$ in. with $2\frac{1}{2}$ gal. of

asphalt per sq. yd. When the stone is so rolled that the roller does not make a track on the stone, but before the stone begins to break up under the roller, the top course is ready for the bituminous material.

The Penetration. — The engineer in charge of the bituminous work should now carefully inspect every square foot of the surface where he intends to apply the asphalt, to see that there are no depressions and that the stone is clean and of proper depth. Special care should be taken to see that the edges of the road are straight and neat, and that dirt from the shoulders has not been allowed to enter the top stone, for if the edges are neglected they will be the first to ravel. He should then see that the bituminous material is of the proper temperature and that all the nozzles of the sprayer are absolutely clean.

Having looked after the details, word may be given to go ahead and apply the bitumen. If asphalt is used it should be heated to a temperature of about 350 degrees and applied under a pressure of 60 lbs. per sq. inch, at a rate of $1\frac{3}{4}$ gal. per sq. yd., either with a motor-distributor or with a wagon-sprayer, but not with a single nozzle. If the distributor streaks and does not apply the asphalt uniformly, it should be stopped at once and either removed from the top stone while the nozzles are being cleaned, or a trough should be put under the nozzles while they are dripping and being cleaned.

When the load is being applied, one or two men should walk along on either side of the sprayer, and whenever a puddle or fat spot is seen, a pick or light-pointed bar should immediately be used to open up the stone and if possible let the asphalt down into the stone to prevent the puddle. If this is not done in a few seconds after the asphalt is sprayed, the asphalt will have set up and then the only way to correct the defect will be to cut out the top stone, replace it with clean stone, re-roll and penetrate again.

After the load has been distributed on the road, and before the asphalt is covered with pea stone, the engineer should carefully examine the surface to make sure that there are no white streaks or spots that have been missed. If any are found they should be carefully patched with a pouring can.

Having examined the surface and found it O. K., pea stone should at once be uniformly and lightly thrown upon the asphalt while it is still hot, and the surface should be rolled. The application of pea stone should be so light that the roller at all times will be bearing on the #1 stone and not on a cushion of pea stone. If the wheels of the roller stick to the asphalt, as they probably will in warm weather, they should be oiled. More pea stone should be added as the rolling takes place, until the surface has an even texture with the voids mostly filled, but with no loose or surplus pea stone on the surface.

In spreading the pea stone, care should be taken to keep back about 12 in. from the edge of the spray along the middle of the road, so that there will be less chance of getting a puddle along the joint due to overlapping when the second half of the road is sprayed.

Having covered the first application of asphalt with the proper amount of pea stone, and having thoroughly rolled the surface, then the surface should be swept clean of all surplus pea stone and the seal coat applied.

The Seal Coat. — The seal coat should be applied at a rate of not over $\frac{1}{2}$ gal. per sq. yd. It is even more important than with the Penetration work that the asphalt be hot and the nozzles clean, for the distributor is moving about four times as fast while applying the seal coat. Tar paper or building paper should be spread down on the road and covered with sand, at the point where the distributor is to be opened up, and the distributor should start far enough back from the point where it proposed to begin spraying so that it will have a flying start and be going at the proper speed when the nozzles are opened. After the load has been applied, the asphalt which landed on the paper is wrapped up and thrown to one side and if the work has been properly executed there will be a straight line joint where the seal coat started, without a surplus of asphalt on the portion already sealed.

If the work has been carefully done, the surface should not have a blot or fat spot in it, and I consider a blot a defect in the road. These fat spots may be caused by dirty stone, stone too small, or spread too thin or overlapping either at the center

joint or at the beginning or end of a load, — all of which can and should be avoided in order to get perfect results.

The seal coat is now covered with pea stone, using about the same method as outlined above for the Penetration course, that is being careful not to put too much on at any one time, keeping it free from bunches and keeping the roller going while the seal coat is still hot.

This final covering of pea stone should consist of just a little more than will stick to the road; it should be broomed about uniformly, and thoroughly and carefully rolled, this final rolling being very important, for there is then no danger of breaking up the #1 stone. A 12 to 15 ton roller is better than the 10 ton roller for this final work.

Not a single load of binder should be applied except when there is an inspector or engineer present. After applying both the penetration work and the seal coat, the bituminous material that overlaps on the shoulders should be trimmed off to the line of the edges of the broken stone, in order to get a good clean-looking line along the edges of the road.

I have been speaking, up to the present, of the asphalt penetration, for I believe that the asphalt penetration is, in most places, superior to the tar. However, they are both used in Bituminous Macadam roads, and the same methods for carrying on the work should be used with either material. Asphalt probably has a longer life than tar and if properly used will require less maintenance. Tars may be used with certain local stones where the travel is not too heavy, with more success than asphalt, for tar will work its way into smaller voids than asphalt and works down into the road with travel and hot weather, while asphalt works both upward and downward.

Bituminous Macadam for Resurfacing

The Bituminous Macadam road has been used extensively and successfully to resurface the old waterbound macadam surfaces, and in this field it can be most economically used, for in many places the old macadam surface will furnish the necessary base for a new 2 in. wearing surface. When built in this way care should be taken to locate the spots that rut in the

spring or break with frost, and they should be strengthened or subgraded.

Built with Road Open to Travel

The Bituminous Macadam construction is perhaps the easiest modern pavement to build one-half at a time while the road is kept open to travel. It can be built in 1,000 ft. sections, — first on one side of the road and then leaving a distance of a few hundred feet for a turnout, building 1,000 ft. on the other side of the road. With half a dozen flagmen, work can be underway on three 1,000 ft. sections at the same time, and just as soon as one section is finished it can be opened up to travel and the work shifted over to the other side. This of course cannot be done on any road where cement concrete is used, for the concrete must be given time to set up.

I have looked after several miles of work where the road has been built one-half at a time, and have obtained results just as good as if the whole road had been built at the same time. It should be added that the width of construction was 20 ft. on some of this work. It is very difficult to get good results in building an 18 ft. road one-half at a time, on account of difficulties in rolling. It is true, however, that the work of the inspector is greatly increased and also the cost to the contractor, if the road is built one-half at a time.

I obtained some data as to the increased cost of building one side at a time and allowing traffic on the other side on the Boston and Worcester road, a portion of which was built in 1917 the full width at one time, and part in 1918 one-half at a time. This data showed that for the actual work that takes place *on the road*, including the flagmen and watchmen, the costs of excavation, spreading and rolling the bottom stone and spreading and rolling the top stone increased between 40 and 50%. Of course the work that takes place *off the road* would not be affected, such as the breaking and crushing of stone or the initial cost of stone and asphalt. Considering the total cost of the entire pavement, built one-half at a time, the increased cost would be about 15%.

Another item of importance is the season of the year in which Penetration work should be done. I do not believe that

perfect results can be obtained on work done after the middle of September. Work finished previous to July 1st or August 1st is usually much better than work finished after October 1st. The reason for this is that work done in the early summer gets the benefit of being rolled during the hot weather, and the travel and sun help to bond the stone and the asphalt.

When work is done in the fall, it means spraying the bitumen into cold and perhaps damp stone. The stone may not look damp on top, but is very liable to be so beneath the surface. The hot bitumen cools off the minute it strikes the surface and consequently there is not good penetration. Then the roller goes over the surface and instead of the stone and asphalt becoming firmer under the rolling, the slight bond that exists is likely to break and the stones of the top surface are covered with asphalt but not thoroughly bonded together. Then a seal coat is put on, hoping to strengthen the bond, and it is undoubtedly strengthened on the surface, but the stones below are still not properly bonded. If travel could be kept off until the following summer, and the surface then thoroughly rolled, good results would probably be obtained but the road is generally thrown open to travel with weather conditions such that the road does not improve in the way that it does in the summer. Consequently it is usually only a short time before raveling takes place, especially if there is snow, and ice ruts are formed. Under these conditions blame is often placed either on the asphalt or on the construction, when in fact, the chief blame is probably due to the weather conditions. If Bituminous Macadam must be built late in the fall, it should be kept well covered during the winter with a clean, coarse sand, in order to keep the travel off the road metal.

Maintenance

There are on the State roads of Massachusetts today approximately 555 miles of Bituminous Macadam surfaces, of which 35 miles are of the old Hot Oil type and 520 miles are of the modern types. The modern type may be further divided into two classes, — Asphalt Penetration and Tar Penetration, — there being about 260 miles of each. This compares with a

total of about 270 miles for all other types of modern surfaces, — such as Bituminous Concrete, Cement Concrete and Block Paving. Thus, it will be seen that there are about twice as many miles of Bituminous Macadam roads as of all other modern types combined.

The amount and the type of maintenance and its cost on any particular Bituminous Macadam road will depend a great deal on the season of the year in which the road was built, and the results obtained in the construction. A surface without proper foundations, which is wavy, and has either too much or not enough bitumen, will obviously need much more attention and will cost more to maintain than a road properly designed and built with a perfect surface.

It is therefore difficult to outline any one organization which could handle economically all kinds of maintenance. An ideal organization in one locality might not be the right size in another.

It is a well known fact that the maintenance on any road should begin the day the road is finished, and the foreman should always be alert for any weakness that may develop in the surface. "A stitch in time saves nine" applies as much to the surface of the road as it does elsewhere.

The winter maintenance of these roads should consist in keeping them covered with sand, if built late in the season, and in keeping the ice ruts sanded when they reach the road surface.

In the early spring when the road is damp and moist and cracks appear in the surface, it is usually due to moisture in the subgrade, and at that time the road should be kept covered with sand until the surface dries out.

Where patches must be made on a good surface, they should be of the same material as that of which the road was built. It is recommended that the hole be cut out square, going back far enough to insure a good joint. Then place #1 stone carefully in the hole, roll, patch and re-roll until a straight-edge resting on the edges of the old surface will just touch the new stone. If the patch is a little low, do not assume that the pea stones will bring it up, for they will not. Paint the edges of the

hole with hot asphalt or tar and spread sand around the hole to prevent the overlapping of the bitumen on the old surface. Pour in the hot bitumen, cover with pea stone lightly, broom and roll. Sealing can be done at this time, or later when "paint patching" is being done on the rest of the road.

This "paint patching" consists of painting the surface with hot bitumen and covering with pea stone. Much work and expense can be saved by its use where the surface shows signs of disintegration, for if left unpainted, holes will usually develop. Tar should be used for painting tar roads and asphalt on asphalt roads.

An ideal organization and equipment for this kind of work is a Ford truck, containing sand, pea stone, wood and tools, etc. — hauling a 50 gallon kettle. Add to this one man sweeping the road ahead, a second man applying bitumen with a broom or pouring pot, and a third man covering with pea stone or sand, tending the fire and doing miscellaneous work.

Bunches. — Care should be taken not to apply too much bitumen in cold weather or bunches will develop in warm weather. Where bunches do develop, they can be most easily removed with a wedge-pointed pick, kept very sharp.

Machine-mixed Patching Material. — During the spring of the year, when there is much patching to be done on some of the old Penetration roads, we have found it advisable to set up a mixing plant at some central point, in order to turn out a cold patch mixture to repair all the roads as quickly as possible. In making these patches, care should be taken to use #1 or #2 stone in the deeper holes and chestnut stone or pea stone in the small holes. Where #1 stone is used in the deep holes, we have found it advisable to feather off with a pea stone mixture. Later we seal with either tar or asphalt to keep the water out and prevent disintegration.

I am in favor of machine-mixed cold patch material, as there is a saving of about one-third in the amount of bitumen used, and the stone is more uniformly and thoroughly coated, and the cost is much less.

On every Bituminous Macadam road there probably comes a time when a maintenance seal coat is desirable. On Tar

roads this time will probably come during the second or third year, and I recommend using an asphalt seal coat, providing the tar surface is in such shape that it will take the asphalt. If the asphalt cannot be applied successfully, I would then prefer a tar of the consistency of Tarvia A. However, if the road has been previously treated with cold tar, it is doubtful whether either of the above seals could be applied successfully. In that case probably a cold tar should be used.

The Asphalt roads will last for a much longer time without this maintenance seal coat. A well-built Asphalt Penetration surface should go at least six years. In Weston, where a native asphalt was used, there has been no maintenance seal coat in ten years, and in Dracut, where five different kinds of oil asphalts were used in 1913, the surface is still unsealed except for the seal coat applied when the road was built.

Conclusion

In concluding this paper, I shall give some statistical data obtained from a piece of experimental Bituminous Macadam construction, built by the State in 1913, on which the writer was the resident engineer.

This road, which is in Dracut, between the cities of Lowell and Lawrence, is $3\frac{1}{4}$ miles in length. It was subgraded with from 6 to 12 in. of gravel, and the wearing surface, 2 in. thick, was built on top of a 4 in. macadam base with a good grade of local stone, part of which resembled a commercial trap.

Six sections, approximately $\frac{1}{2}$ mile each in length, were built of asphalt, using five different kinds of oil asphalt and one native asphalt, making a total of three miles of Asphalt Macadam. The remainder, about $\frac{1}{4}$ of a mile, was penetrated and sealed with tar.

This road has now been under maintenance nine years. At no time has the writer had any part in this maintenance or in the keeping of the costs. From the Maintenance Engineer in charge of this road I obtained the information that no money was spent on the surface of this entire road last year, and also that the average cost per mile per year for the asphalt portion was less than $28. The tar portion was higher, on account

of having been sealed, but because there was only $\frac{1}{4}$ mile of it, it does not seem fair to compare it with the asphalt.

Among other well-constructed Bituminous Macadam Asphalt roads, where the maintenance costs have been very low, the following may be mentioned:

(1) Weston, 3 miles in length, built in 1912 and 1913, without foundations, where the cost has run $90 per mile per year.

(2) Concord, built in 1918 and 1919, $3\frac{1}{2}$ miles in length, where the cost has run $62 per year for the first piece built in the fall of the year, and $40 per mile per year for the second piece built in the summer.

(3) Lexington, from East Lexington to Lincoln, 3.4 miles in length, built in 1918, where the cost has been $26 per mile per year.

(4) Sudbury and Lincoln, $2\frac{1}{3}$ miles and 2 miles respectively in length, built in 1916, where costs have run $52 per mile per year and $37 per mile per year.

Summarizing the data of the above roads (all of which except Weston were built under the supervision of the writer) we have approximately 18 miles of Bituminous Macadam road, built for the most part five to ten years ago, which has cost less than $50 per mile per year to maintain.

This shows the possibilities of the well-constructed Bituminous Macadam road, where proper attention has been given both to design and to the details of construction.

In contrast with these low costs the average cost for surface maintenance throughout the whole State for the year 1922 was approximately $400 per mile for Bituminous Macadam Tar, and $200 per mile for Bituminous Macadam Asphalt.

These figures compare with $100 per mile per year for Cement Concrete, but in making the comparison it should be remembered that the cement concrete road, as built today, will probably cost $10,000 more per mile to build, and the interest on this $10,000 should be considered.

In fairness to both types, I believe that the Cement Concrete road is the best road we are building; however, I think

there are many places where the Cement Concrete road is not justifiable and in many of these places the Bituminous Macadam Asphalt road can be built and maintained more economically than the concrete, that is when all maintenance costs are considered, as well as interest and depreciation on the investment.

ACTIVITIES OF THE FEDERATED AMERICAN ENGINEERING SOCIETIES

The Quantity Survey Problem

In the F. A. E. S. campaign for the elimination of waste in industry, those organizations which were interested in the quantity survey problem were brought together to develop a set of recommendations whereby it was hoped to prevent the large item of waste which is due to the necessity of making separate quantity surveys by each bidder on a contract. The organizations that developed and approved these recommendations were the American Institute of Architects, the Associated General Contractors of America and the American Engineering Council of the Federated American Engineering Societies.

The engineers recognized an opportunity to be of possible assistance to those engineers engaged in construction work and to save prospective owners and others financially interested the expense of the wasteful duplication involved in the estimation of quantities of materials entering into the project. In its ramifications this means a considerable saving to municipal, state and Federal governments, as well as to private owners.

The recently established Quantity Survey Bureau in St. Louis emphasizes the fact that possibly conditions in Boston will justify a survey of the situation there so that if it were found feasible, a similar bureau could be established. There are two ways in which the wastes in quantity surveys may be eliminated, — either by having the architect and the engineer prepare the quantity survey and submit it to the owner with his plans, or to adopt the plan now generally used in other cities of having this work done by a Quantity Survey Bureau established especially for this purpose.

The following is quoted from the announcement of the establishment of a Quantity Survey Bureau at St. Louis:

"The object of this bureau is to eliminate the present duplication of effort and expense in the purely mechanical operation of taking off items of excavation, concrete (plain and reinforced), brickwork, and lumber bills, these being the quantities most frequently estimated by the general contractor.

"The bureau will serve not only as an arithmetical check of quantities; a clearance of indefinite items in plans and specifications by conference of the bureau with the designer; a reduction in number of extras to owner; a saving in time required to bid; an insurance as to quality and quantity of materials needed for the project; but as a material reduction in the cost of maintaining large individual estimating bureaus.

"The Quantity Survey has nothing whatever to do with prices, and is not related to price fixing. It merely accurately determines the quantity of construction material required to complete a definite structure."

The experience of other cities, namely New York, Chicago and Milwaukee, indicates that such a bureau is valuable to the owner and contractor and of indirect value to all those having to do with the parts of the work where quantity surveys of any kind are required. Further than this, these quantity survey bureaus have long been in existence in England and other foreign countries.

Owners and investors, whether they be private or public organizations, should realize that all expenses in the planning of buildings and construction must necessarily be paid by them. Those who build know that none can afford to work without fair compensation for services rendered, but they probably do not realize that due to practices in vogue they pay for the cost of the preparation of all bids, including that of the successful bidder. Generally speaking, it has been the practice to have figures submitted by the successful bidder include an amount sufficient to cover the work entailed in making proposals on other work which he was not successful in securing. In short, his overhead account is much larger than it necessarily should be and for all of this the owner must pay. To eliminate the duplication of effort in estimating, thereby reducing the contractor's overhead with the attendant reduction in the cost of building, requires that all bids be submitted on the same basis and in such manner that they may be readily analyzed.

The owner should not be required to pay a contractor an overhead charge which includes any other costs than belong to

the particular project. It is believed that this can be accomplished by having an itemized list made of all quantities entering into the proposed work. The owner should pay for the preparation of this itemized list whether he proceeds with the building or not. It is obvious that such payment will be much less when such list is furnished, as each bidder is furnished with the list of quantities called the Quantity Survey and each bidder is thereby released from the work of separately taking off the quantities from the drawings and specifications.

A quantity survey, because it fixes definite quantities on which the bids are to be received, eliminates speculation on the part of the bidders as to the quantities involved in the project and thus makes possible lower bids due to the elimination of this "contingency." Where the owner does not avail himself of the quantity survey procedure recommended herein, he should pay selected bidders directly for estimating work on a pre-arranged basis rather than have all his bids increased by an unknown amount for estimating quantities, which, frequently in current practice, the successful bidder distributes among the unsuccessful bidders in accordance with a pre-arrangement of the bidders.

A quantity survey places all contractors on the same basis, which is a definite one, from which they may price or determine the proper cost of the work. Each individual item of cost as set out in such quantity survey should be a basis of determining the proper cost of extra work desired by the owner as well as a basis for credits on account of omissions; it also has the added advantage of enabling contractors to audit and prepare monthly statements, progress reports, etc.

It will be remembered that at a recent conference of the Associated General Contractors of America, the matter of the value of quantity surveys by bureaus located in the important cities was discussed in some detail. Certain contractors were opposed to the general practice, but the discussion seemed to indicate that in every center where such a bureau had been established, it had proved to be a valuable asset. The quantity survey bureau in Milwaukee, for instance, has been in operation for nearly ten years, and representatives from that district stated

that it was absolutely indispensable and that they would never go back to the old plan of making separate quantity surveys. While it is recognized that these bureaus may not be so valuable in some communities as in others, their possibilities should be recognized, and an investigation would immediately show whether they could expect to be successful.

MEMOIR OF DECEASED MEMBER

LAWSON BENNETT BIDWELL*

Lawson Bennett Bidwell died November 19, 1922, at his home in Hyde Park, Massachusetts.

Mr. Bidwell was born at South Lee, Massachusetts, March 30, 1833, the elder son in a family of five daughters and two sons. His father, Lawson Dench Bidwell, attended Williams College and practiced law, first in Tyringham (now Monterey) and afterwards in South Lee and Stockbridge, at the same time running a good-sized farm.

The subject of this memoir attended the public schools and spent about two years at Williams Academy at Stockbridge, where he paid for his tuition by ringing the bell. He was most interested in mathematics, and while at the academy he showed his ingenuity by graduating a circle and attaching it to a spirit level mounted on a tripod. This apparatus was used for a time at the academy for measuring the elevation of distant objects. With the assistance of the village blacksmith he made a surveyor's compass and chain and surveyed the home farm, establishing on the mountain a line which had long been in question.

In May, 1853, he left the farm and obtained employment as a rodman on the Hartford, Providence & Fishkill R.R., which was then under construction from Willimantic, Conn., to Providence, R. I., and from Bristol to Waterbury, Conn. He was first located at North Windham. After 14 months' service, he was promoted to the position of Assistant Engineer.

After the road was opened to traffic, he was Engineer and Roadmaster until January, 1857, working under Samuel Ashburner, who was Chief Engineer and Manager.

* Memoir prepared by George T. Sampson and George F. Swain.

The winter of 1857 was very cold and severe, with heavy falls of snow, and the duties of a roadmaster brought many trials. After an unusually bitter experience with drifted tracks and frozen water tanks, involving long and severe exposure between Hartford and Waterbury, Mr. Bidwell reported to the Superintendent at Hartford that he preferred farming to railroading in winter. Soon afterwards he left the railroad employ and went back to Stockbridge, Mass.

On November 18, 1857, he was married to Henrietta W. Brewer, a most worthy lady, whose uncle, Stephen J. Field, was one of the Justices of the Supreme Court of the United States, and whose brother, David J. Brewer, later occupied the same position. Mrs. Bidwell passed away March 14, 1901.

Mr. Bidwell next bought a quarter-interest in the Agawam Flour Mills at West Springfield, Mass., and acted as salesman in Springfield for about a year, when he sold out and went back to the farm at Stockbridge, which he carried on for about three years.

In 1863 he went to Kansas as a transitman on the Eastern Division of the Union Pacific R.R., and a few months later was put in charge of a party.

In May, 1864, he came back to the Hartford, Providence & Fishkill R.R. as Engineer and Roadmaster, reporting to the Superintendent, Mr. Samuel Nott, who was Secretary of this society from March 6, 1849 to August 7, 1874. Mr. Bidwell had previously worked with Mr. Nott on the construction of the railroad, and they continued to be associated for many years. The Hartford, Providence & Fishkill R.R. had been in operation from Providence to Waterbury ($122\frac{1}{2}$ miles) from July 11, 1855, and on January 1, 1858, it failed to pay the interest on its mortgage bonds. On February 1, 1858, the title was transferred to the trustees under the mortgage, who continued to operate the property until October 18, 1878. Projected as a through line to the west from Providence and Hartford, but with no immediate prospect of constructing its extension west of Waterbury, the railroad was entirely dependent on local traffic. Each of the larger cities and towns through which it passed was served by another railroad more favorably located for securing traffic.

Under these conditions, the operating results were so uncertain that seasons of alternate hope and despair succeeded each other in the effort to break even financially. Such conditions taxed the ingenuity, patience and loyalty of all of the officers and employees, and the most rigid economy was necessary. The trustees succeeded in maintaining the physical unity of the property, and there was a slow growth and improvement in the territory served, but the earnings never proved sufficient to lift the road out of its financial difficulties or to make even its bonds attractive. The bond holders therefore voted to transfer title on payment of the mortgage lien.

The right to redeem the mortgage bonds was acquired by the New York & New England R.R. Co., and upon payment of the mortgage, possession of the road was surrendered October 18, 1878, under a decree of the United States Court, to the New York & New England R.R. Co.

Under such harassing circumstances, Mr. Bidwell worked faithfully and loyally, gaining experience of great benefit to his employers and to himself in the following years.

In 1874, he located and superintended the construction of the Pawtuxet Valley Branch from River Point to Hope, R. I. In May, 1879, he was appointed Chief Engineer of the New York & New England R.R. Co., and transferred his residence from Hartford, Conn., to Hyde Park, Mass. The years following called for continuous application, as the company at once initiated a policy of expansion which required, in many places, construction work of great variety and on a large scale. The extension of a second track was started that year from Winslows to Walpole, Mass., and from Hartford easterly. A relocation was made of the line of the partially graded road bed from Waterbury westerly for 65 miles to Hopewell Junction, N. Y. The road therefore became an east and west cross country line, with much rise and fall from one water shed to another and requiring very heavy work of grading and masonry, together with many important bridges.

Contracts for this extension were soon awarded and the work progressed rapidly. Mr. Bidwell gave much personal attention to it, and at the same time superintended the work

on the terminal yard at Fishkill on the Hudson, where large areas of land and tide water flats had been purchased, where much dredging and filling had to be done, and where engine house, turn table, water tanks, freight house, and passenger station had to be erected. Many miles of side-tracks were laid on the newly-filled land, and a ferry slip and landing bridge was built. The transfer ferry "William T. Hart" was built and put into service as soon as the line was completed, thus affording connection by ferry with the Erie R.R. and the New York, West Shore & Buffalo R.R. at Newburgh. The "William T. Hart" was a fine steamer for those days, with three tracks on its deck and capable of transferring 24 freight cars at one time. Having a steel hull and powerful engines, it was able to maintain service throughout the year, even when there was heavy ice in the river. The design, construction and maintenance of the ferry slip and bridges to accommodate the steamer were works of merit, which Mr. Bidwell accomplished with great success.

Construction on the western extension progressed so that the line was opened for traffic from Waterbury to Danbury on July 24, 1881, and from Danbury to Hopewell Junction and from Wicopee Junction to Fishkill and Newburgh in January, 1882. While this work was in progress, construction work was being done on the South Boston freight terminal, where large areas of flats were filled with material dredged from the harbor, necessary side-tracks laid, driveways paved, freight houses and buildings erected, and warehouses to accommodate ocean steamships built on two piers. The dock walls for another pier were built at this time, but the warehouse on it was not erected until 1895.

Second-track extension work was completed from Walpole to Franklin (8 miles) in 1882, from Franklin to Blackstone (9 miles) in 1883, from Blackstone to Willimantic (50 miles) in 1884, and on other parts of the line in later years. With the opening of the western extension there was a great increase in traffic, which required increased side-track and yard facilities, water supplies, coaling stations, station buildings, etc. To handle the increased traffic, heavy locomotives and rolling stock

were purchased, and many bridges were either reinforced or entirely rebuilt. Mr. Bidwell was especially well-informed on bridge matters and took great personal pains to keep informed on the design, strength and condition of all structures on the line. Indeed the manner in which he kept his bridges safe at low cost was greatly to his credit and added to his reputation. It is easy to condemn a bridge and build a new one, but it is not so easy to keep an old bridge safe. His ingenuity in strengthening and repairing structures was evident in the manner in which he kept the older bridges in service, the last of them, between Providence and Willimantic, not being replaced until 1911.

About 1882 land was purchased and the large freight transfer and car storage yard at East Hartford was built. In 1886 the original wooden truss bridge over the Connecticut River at Hartford was replaced by a seven-span wrought-iron truss bridge. Other extensive improvements were carried on at Hartford, Providence, and other places, and an extension of the Norwich & Worcester line from Allyn's Point to Groton, Conn., was located and built.

To Mr. Bidwell belongs the credit of developing the first preliminary plans for the South Station in Boston, with its yard, tracks and approaches. Mr. Bidwell served as one of the consulting engineers in the making of the final plans and during the construction of this station, and his name is engraved on the granite tablet at the main entrance.

After July 1, 1898, when the New England R.R. was leased to the New York, New Haven & Hartford, Mr. Bidwell served as Principal Assistant Engineer of the Eastern District, in charge of lines east of New London and Willimantic. This work offered abundant opportunities for the exercise of his skill and experience. He supervised the preparation of plans and estimates for the elimination of grade crossings at many places, and had charge of construction work of large amount.

Mr. Bidwell was President of the Boston Society of Civil Engineers in 1901. He retired from active service with the railroad June 1, 1905, and thereafter lived quietly at his home on Fairmount Avenue in Hyde Park, making occasional trips to other and distant parts of the country. Mr. Bidwell was a

member of the Hyde Park Congregational Church, and took an active interest in its service.

He was married in 1903 for the second time, to Arianna Davis, who survives him. He also leaves a brother, Charles A. Bidwell of Stockbridge, a daughter, Mrs. Alice H. Lee of Boston, a daughter-in-law, Mrs. Jane R. Bidwell of Brookline, a daughter by adoption, Mrs. Florence B. Turner, and three grandchildren.

Mr. Bidwell was an excellent engineer, and had the respect and admiration of all members of his profession who knew his work. He was unassuming in manner, genial in disposition, beloved by all who knew him, devoted to his home and loyal to his work, and he lived an earnest and useful life. Nothing more can be expected or wished of any man.

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BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

PROCEEDINGS

APPLICATIONS FOR MEMBERSHIP

[September 15, 1923]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Transfer from Grade of Junior

LUCAS, JOHN, Portsmouth, N. H. (Age 23, b. Bury, Eng.) Graduate of Mass. Inst. of Tech. 1920. 1920–21, assistant engineer with Jackson & Moreland; 1921–22, assistant highway engineer, Illinois State Highway Commission; May, 1922, to May, 1923, contracting engineer, Chicago Bridge & Iron Works; May, 1923, to the present time, civil engineer, Sinclair Refining Co. Refers to J. B. Babcock, C. B. Breed, E. H. Cameron, E. L. Moreland, C. M. Spofford and H. Sutherland.

LIST OF MEMBERS

Additions

Hamilton, Edward P.	66 Broadway, Lowell, Mass.
Rice, Percival S.	26 Welles Ave., Dorchester, Mass.
Robbins, James M.	42 Oak St., Belmont, Mass.
Safford, Truman H.	66 Broadway, Lowell, Mass.
Titcomb, Albert C.	120 Tremont St., Boston, Mass.

Changes of Address

Barry, C. Gardner	11 Joy St., Boston, Mass.
Brask, Henry	94 Gainsborough St., Suite 2, Boston, Mass.
Brown, Howard L.	196 River St., West Bridgewater, Mass.
Brown, Oliver B.	Metropolitan District Com., 1 Ashburton Pl., Boston, Mass.
Cashman, John M.	96 Fayette St., Watertown, Mass.
Crossman, Hartwell H.	10 School St., Attleboro, Mass.
Curtis, Allen	16 Mason St., Gloucester, Mass.
Danforth, George C.	16 Marlborough St., Boston, Mass.
De La Haye, E. F.	984 So. Atlantic Ave., Daytona Beach, Fla.
Deming, Guy S.	Long Valley, N. J.
Durgin, Clyde M.	800 Turks Head Bldg., Providence, R. I.
Eberhard, Walter C.	35 Shirley Rd., Waltham, Mass.
Green, Howard W.	206 Electric Bldg., Cleveland, O.
Haley, F. William	933 Worcester Rd., Framingham, Mass.
Hunter, Harry G.	598 Union Ave., Montreal, Canada.
Krigger, A.	196 Fayerweather St., Cambridge, Mass.
Lucas, John	206 Rockland St., Portsmouth, N. H.
McInnes, Frank A.	236 Bay State Rd., Suite 11, Boston, Mass.
Mirick, George L.	184 Savin Hill Ave., Dorchester, Mass.
Nichols, John R.	161 Devonshire St., Boston, Mass.
Raymond, John W., Jr.	South Hamilton, Mass.
Smilie, Edward S.	352 Center St., Newton, Mass.
Wade, Clifford L.	The Makiki Hotel, 1429 Makiki St., Honolulu, Hawaii.
Webb, De Witt C.	Public Works Office, Naval Base, San Diego, Calif.
Winslow, Earl H.	335 Highland Ave., Wollaston, Mass.
Worcester, Robert J. H.	c/o Lockwood, Greene & Co., 804 E. North St., Greenville, S. C.

LIBRARY NOTES

Recent Additions to the Library

U. S. Government Reports

Trade Association Activities. U. S. Dept. of Commerce.

U. S. Census, 1920. Vol. IX, Manufactures.

Water Supply Papers, Nos. 469, 495, 496, 501, 504, 510 and 512.

State Reports

Massachusetts. Annual Report of Metropolitan District Commission. 1922.

Massachusetts. Annual Report of Public Works. 1921 and 1922.

New Hampshire. Annual Report Public Service Commission. Sept., 1918, to Dec. 31, 1920.

South Carolina. Report of State Board of Health. 1923.

Municipal Reports

Brockton, Mass. Annual Report of Board of Survey. 1922.

Brockton, Mass. Annual Report of City Engineer. 1922.

Brockton, Mass. Annual Report of Sewerage Commissioners. 1922.

Cambridge, Mass. Annual Report of Water Department. 1921.

Haverhill, Mass. Annual Report of Board of Water Commissioners. 1922.

Holyoke, Mass. Annual Report of Board of Water Commissioners. 1922.

Leominster, Mass. Annual Report of Water Commissioners. 1922.

New Bedford, Mass. Annual Report of Engineering Department. 1922.

New Orleans, La. Addresses at Dedication of Inner Harbor Navigation Canal, May 5, 1923.

New Orleans, La. Annual Report of Board of Commissioners of the Port.

New Orleans, La. Annual Report of Sewerage and Water Board. 1922.

New York, N. Y. Annual Report of Bureau of Buildings. 1922.

North Adams, Mass. Annual Report of City Government. 1922.

Providence, R. I. Annual Report of Bureau of Water. 1921.

Reading, Pa. Annual Report of City Engineer. 1922.

St. Paul, Minn. Annual Report of Board of Water Commissioners. 1922.

Taunton, Mass. Annual Report of Water Commissioners. 1922.

Waltham, Mass. Annual Report of Department of Public Works. 1922.

Miscellaneous

American Electricians' Handbook. Terrell Croft.

American Machinists' Handbook. Colvin and Stanley.

American Society of Heat. & Vent. Engrs. Guide. 1922.

A. I. E. E. Standards. 1922 Revision.

Catalog of Technical Periodicals. Alice J. Gates.

Chemical Engineering Catalog. 1922.

Condensed Catalog of Mechanical Equipment. 1922.

Electrical Vibration Instruments. A. E. Kennelly. Gift of D. C. Jackson.

E M F Electrical Yearbook. 1923.

Engineers' Manual. Ralph G. Hudson. Gift of Author.

Engineering Electricity. Ralph G. Hudson. Gift of Author.

Handbook of Electrical Engineers. Pender.

Handbook for Heat. & Vent. Engineers. Hoffman.

Index to Engineering News-Record, 1917–1922 incl.

Life and Times of Alvah Crocker. Gift of Douglas Crocker.

MacRae's Blue Book. Vol. 14. 1923.

Mechanical Engineers' Handbook. Wm. Kent.

Mining Catalog. Metal-Quarry Edition. 1922.

Personnel Administration. Tead and Metcalf. Gift of C. H. Eglee.

Proceedings of Nat'l Elec. Light Asso'n. 1921 and 1922.

Report of Joint New England Railroad Committee. (J. J. Storrow.)

Smoke Abatement and Electrification of Railway Terminals. W. F. M. Goss, Chf. Engr. From library of F. P. Stearns.

Sweet's Engineering Catalog. 1923.

Standard Handbook for Electrical Engineers. Fowle.

Transactions of A. I. E. E. Vols. 32–38 incl. Gift of Stone & Webster Library.

Transactions of A. I. E. E. Vols. 39–41 incl.

Transactions of A. S. H. & V. E. Vols. 1, 3–26 incl.

Year Book of Wireless Telegraphy. London. 1923.

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